Amendments to the Claims

Claim 1 (currently amended): A method of managing distortion in a digital communications transmitter in which at least a portion of said distortion is introduced by analog-transmitter components, said method comprising:

obtaining a forward-data stream configured to convey digital information;

training a linear predistorter <u>which is responsive to said forward-data stream and is located upstream of said analog-transmitter components</u> to compensate for linear distortion introduced by said analog-transmitter components; and

training a nonlinear predistorter <u>which is responsive to said forward-data stream and is located upstream of said analog-transmitter components</u> to compensate for nonlinear distortion introduced by said analog-transmitter components.

Claim 2 (original): A method as claimed in claim 1 wherein:

said linear predistorter comprises a first equalizer, and said nonlinear predistorter comprises a second equalizer;

said linear-predistorter-training activity comprises operating said first equalizer in an adaptive mode to compensate for said linear distortion; and

said nonlinear-predistorter-training activity comprises operating said second equalizer in an adaptive mode to compensate for said nonlinear distortion.

Claim 3 (original): A method as claimed in claim 2 wherein:

said linear-predistorter-training activity operates said first equalizer in a non-adaptive mode when said second equalizer is operated in said adaptive mode; and

said nonlinear-predistorter-training activity operates said second equalizer in a non-adaptive mode when said first equalizer is operated in said adaptive mode.

Claim 4 (original): A method as claimed in claim 1 wherein said nonlinear-predistorter-training activity occurs after said linear-predistorter-training activity.

Claim 5 (original): A method as claimed in claim 1 wherein said linear-predistorter-training activity comprises determining filter coefficients for an equalizer which filters said forward-data stream.

Claim 6 (original): A method as claimed in claim 5 additionally comprising:

down-converting a feedback signal obtained from said analog-transmitter components using a digital-subharmonic-sampling downconverter to generate a return-data stream; and

processing said return-data-stream to generate said filter coefficients.

Claim 7 (original): A method as claimed in claim 6 wherein said processing activity controls one or more estimation-and-convergence algorithms to generate said filter coefficients.

Claim 8 (original): A method as claimed in claim 7 wherein said one or more estimation-and-convergence algorithms are responsive to said forward-data stream and to said return-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said one or more estimation-and-convergence algorithms are configured to transform increased algorithmic processing time into reduced effective-error level for said return-data stream.

Claim 9 (original): A method as claimed in claim 1 wherein said forward-data stream is provided by a peak-reduction section, said analog-transmitter components include a power amplifier which produces a power-amplifier-output signal, and said method additionally comprises:

obtaining an residual value that estimates uncompensated nonlinear distortion introduced by said analog-transmitter components into said power-amplifier-output signal; and

operating said peak-reduction section so that an amount of peak reduction imposed in said forward-data stream is responsive to said residual value.

Claim 10 (original): A method as claimed in claim 9 wherein said operating activity increases said amount of peak reduction when said residual value indicates nonlinear distortion exceeding a predetermined amount.

Claim 11 (original): A method as claimed in claim 1 wherein:

each of said linear-predistorter-training and nonlinear-predistorter-training activities processes a return-data stream obtained from said analog-transmitter components;

said forward-data stream exhibits a forward resolution; and

said return-data stream exhibits a return resolution less than said forward resolution.

Claim 12 (original): A method as claimed in claim 11 wherein said return resolution is at most four bits less than said forward resolution.

Claim 13 (original): A method as claimed in claim 1 wherein:

each of said linear-predistorter-training and nonlinear-predistorter-training activities processes a return-data stream obtained from said analog-transmitter components;

each of said linear-predistorter-training and nonlinear-predistorter-training activities implements an estimation-and-convergence algorithm responsive to said forward-data stream and to said return-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said estimation-and-convergence algorithm controls a rate of convergence to achieve a predetermined effective return-error level that is less than said return-error level.

Claim 14 (original): A method as claimed in claim 1 wherein:

each of said linear-predistorter-training and nonlinear-predistorter-training activities processes a return-data stream obtained from said analog-transmitter components;

each of said linear-predistorter-training and nonlinear-predistorter-training activities implements an estimation-and-convergence algorithm responsive to said forward-data stream and to said return-data stream; and

said estimation-and-convergence algorithm estimates filter coefficients which influence said forward-data and return-data streams, generates an error signal by combining said forward-data and return-data streams, and repetitively revises said filter coefficients to minimize said error signal and to decorrelate said error signal from said forward-data stream.

Claim 15 (original): A method as claimed in claim 1 additionally comprising:

obtaining a return-data stream from said analog-transmitter components;

delaying said forward-data stream to form a delayed-forward-data stream in temporal alignment with said return-data stream;

forming an error signal by combining said delayed-forward-data stream and said return-data stream; and

performing said linear-predistorter-training and nonlinear-predistorter-training activities by implementing an estimation-and-convergence algorithm that converges upon filter coefficients which minimize said error signal.

Claim 16 (original): A method as claimed in claim 15 wherein:

said forward-data and return-data streams are complex data streams; and

said delaying activity comprises delaying said forward-data stream to compensate for common mode delay between said forward-data and return-data streams.

Claim 17 (original): A method as claimed in claim 15 wherein:

said forward-data stream propagates through said nonlinear predistorter and through said linear predistorter in response to a clock signal; and

said delaying activity delays at least a portion of said forward-data stream by an integral number of cycles of said clock signal and further delays said portion of said forward-data stream by a fraction of a cycle of said clock signal.

Claim 18 (original): A method as claimed in claim 1 wherein:

said linear predistorter comprises a first non-adaptive equalizer, and said nonlinear predistorter comprises a second non-adaptive equalizer;

said linear-predistorter-training activity comprises coupling an adaptation engine to said first non-adaptive equalizer to determine filter coefficients for said first non-adaptive equalizer;

said method additionally comprises decoupling said adaptation engine from said first non-adaptive equalizer; and

said nonlinear-predistorter-training activity comprises coupling said adaptation engine to said second non-adaptive equalizer to determine filter coefficients for said second non-adaptive equalizer.

Claim 19 (original): A method as claimed in claim 1 wherein:

said analog-transmitter components include a power amplifier which is driven by a power-amplifier-input signal and which produces a power-amplifier-output signal; and

said linear-predistorter-training activity comprises downconverting said power-amplifier-input signal then downconverting said power-amplifier-output signal.

Claim 20 (original): A method as claimed in claim 1 wherein said nonlinear-predistorter-training activity comprises

generating a plurality of basis-function-data streams, wherein each basis-function-data stream is responsive to $X(n)^{\bullet}|X(n)|^{K}$, where X(n) represents said forward-data stream, and K is an integer greater than or equal to one;

estimating filter coefficients for filters that process said basis-function streams;

filtering said basis-function-data streams in said filters to generate a plurality of filtered-basis-function-data streams;

combining said filtered-basis-function-data streams and said forward-data stream; and

repetitively revising said filter coefficients to compensate for said nonlinear distortion.

Claim 21 (original): A digital communications transmitter comprising:

a source of a forward-data stream configured to digitally convey information;

a nonlinear predistorter coupled to said forward-data-stream source and configured to generate a nonlinear-predistorted-compensation stream from said forward-data stream;

a combiner coupled to said forward-data-stream source and said nonlinear predistorter and configured to generate a nonlinear-predistorted-forward-data stream from said forward-data stream and said nonlinear-predistorted-compensation stream;

a linear predistorter coupled to said combiner and configured to generate a linear-and-nonlinear-predistorted-forward-data stream, said linear-and-nonlinear-predistorted-forward-data stream being routed to analog-transmitter components; and

a feedback section having an input adapted to receive an RF-analog signal from said analog-transmitter components and an output coupled to said nonlinear predistorter and to said linear predistorter.

Claim 22 (original): A digital communications transmitter as claimed in claim 21 wherein:

said analog-transmitter components include a power amplifier which produces a power-amplifier-output signal;

said transmitter additionally comprises a peak-reduction section coupled to said forward-data-stream source and to said feedback section;

said peak-reduction section generates a peak-reduced-forward-data stream so that said nonlinear predistorter and said combiner operate upon said peak-reduced-forward-data stream; and

said peak-reduction section imposes an amount of peak reduction in said peak-reduced-forward-data stream that is responsive to a residual value, said residual value estimating uncompensated nonlinear distortion introduced by said analog-transmitter components into said power-amplifier-output signal.

Claim 23 (original): A digital communications transmitter as claimed in claim 22 wherein said peak-reduction section increases said amount of peak reduction when said residual value indicates nonlinear distortion exceeding a predetermined amount.

Claim 24 (original): A digital communications transmitter as claimed in claim 21 wherein:

said nonlinear predistorter comprises a first equalizer which operates in an adaptive mode to compensate for nonlinear distortion; and

said linear predistorter comprises a second equalizer which operates in said adaptive mode to compensate for linear distortion.

Claim 25 (original): A digital communications transmitter as claimed in claim 24 wherein:

said first equalizer is a first-non-adaptive equalizer configured to be programmed with first-filter coefficients;

said second equalizer is a second-non-adaptive equalizer configured to be programmed with second-filter coefficients; and

said digital communications transmitter additionally comprises an adaptation engine selectively coupled to and decoupled from said first-non-adaptive and second-non-adaptive equalizers and configured to implement an estimation-and-convergence algorithm which determines said first-filter and second-filter coefficients.

Claim 26 (original): A digital communications transmitter as claimed in claim 24 wherein:

said first equalizer operates in a non-adaptive mode when said second equalizer is operating in said adaptive mode; and

said second equalizer operates in a non-adaptive mode when said first equalizer is operating in said adaptive mode.

Claim 27 (original): A digital communications transmitter as claimed in claim 21 wherein:

said nonlinear and said linear predistorters selectively operate in respective training modes; and

said linear predistorter operates in its training mode to compensate for linear distortion prior to operating said nonlinear predistorter in its training mode to compensate for nonlinear distortion.

Claim 28 (original): A digital communications transmitter as claimed in claim 21 wherein said feedback section comprises a complex-digital-subharmonic-sampling downconverter adapted to receive said RF-analog signal from said analog-transmitter components and configured to provide a complex-return-data stream.

Claim 29 (original): A digital communications transmitter as claimed in claim 28 wherein:

said forward-data stream exhibits a forward resolution; and

said complex-return-data stream exhibits a return resolution less than said forward resolution.

Claim 30 (original): A digital communications transmitter as claimed in claim 21 wherein:

said feedback section generates a return-data stream;

said digital communications transmitter additionally comprises a programmable delay element coupled between said forward-data-stream source and said feedback section; and

said programmable delay element is configured to produce a delayed-forward-data stream temporally aligned with said return-data stream.

Claim 31 (original): A digital communications transmitter as claimed in claim 30 wherein:

said forward-data stream is a complex-forward-data stream, and said return-data stream is a complex-return-data stream;

said programmable delay element is a first programmable delay element that adjusts for common mode delay between said complex-return-data and complex-forward-data streams; and

said digital communications transmitter additionally comprises a second programmable delay element coupled between said forward-data-stream source and said feedback section, said second programmable delay element being configured to adjust for differential mode delay.

Claim 32 (original): A digital communications transmitter as claimed in claim 30 wherein:

said forward-data stream propagates through digital said communications transmitter in response to a clock signal; and

said programmable delay element includes an integral section that delays said forward-data stream by an integral number of cycles of said clock signal and includes a fractional section that delays said forward-data stream by a fraction of a cycle of said clock signal.

Claim 33 (original): A digital communications transmitter as claimed in claim 30 wherein:

said digital communications transmitter additionally comprises a correlator having inputs coupled to said programmable delay element and to said feedback section; and

said correlator is configured to implement an estimation-and-convergence algorithm to bring said delayed-forward-data stream into temporal alignment with said return-data stream.

Claim 34 (original): A method of managing distortion in a digital communications transmitter in which at least a portion of said distortion is introduced by analog-transmitter components, said method comprising:

obtaining a forward-data stream configured to convey digital information;

obtaining an RF-analog signal from said analog-transmitter components;

generating a return-data stream from said RF-analog signal;

implementing a first-estimation-and-convergence algorithm to train a linear predistorter to compensate for linear distortion introduced by said analog-transmitter components; and

after training said linear predistorter, applying a second-estimation-and-convergence algorithm to train a non-linear predistorter to compensate for nonlinear distortion introduced by said analog-transmitter components.

Claim 35 (original): A method as claimed in claim 34 wherein said forward-data stream is provided by a peak-reduction section, said analog-transmitter components include a power amplifier which produces a power-amplifier-output signal, and said method additionally comprises:

obtaining an residual value that estimates uncompensated nonlinear distortion introduced by said analog-transmitter components into said power-amplifier-output signal; and

operating said peak-reduction section so that an amount of peak reduction imposed in said forward-data stream is responsive to said residual value.

Claim 36 (original): A method as claimed in claim 35 wherein said operating activity increases said amount of peak reduction when said residual value indicates nonlinear distortion exceeding a predetermined amount.

Claim 37 (original): A method as claimed in claim 34 wherein said first-estimation-and-convergence and said second-estimation-and-convergence algorithms are each responsive to said forward-data stream and to said return-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said first-estimation-and-convergence and second-estimation-and-convergence algorithms are configured to transform increased algorithmic processing time into reduced effective-error level for said return-data stream.

Claim 38 (original): A method as claimed in claim 34 wherein:

each of said implementing and applying activities processes said return-data stream;

said forward-data stream exhibits a forward resolution; and

said return-data stream exhibits a return resolution less than said forward resolution.

Claim 39 (original): A method as claimed in claim 38 wherein said return resolution is at most four bits less than said forward resolution.

Claim 40 (original): A method as claimed in claim 34 wherein:

each of said implementing and applying activities processes said return-data stream;

each of said first-estimation-and-convergence and second-estimation-and-convergence algorithms is responsive to said forward-data stream and to said return-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said first-estimation-and-convergence and said second-estimation-and-convergence algorithms each control a rate of convergence to achieve a predetermined effective return-error level that is less than said return-error level.

Claim 41 (original): A method as claimed in claim 34 wherein:

each of said implementing and applying activities processes said return-data stream;

each of said first-estimation-and-convergence and second-estimation-and-convergence algorithms is responsive to said forward-data stream and to said return-data stream;

said first-estimation-and-convergence and second-estimation-and-convergence algorithms each estimate filter coefficients which influence said forward-data and return-data streams, generate an error signal by combining said forward-data and return-data streams, and repetitively revise said filter coefficients to minimize said error signal and to decorrelates said error signal from said forward-data stream.

Claim 42 (new): A digital communications transmitter comprising:

analog transmitter components;

a feedback section adapted to receive an RF-analog signal from said analog-transmitter components;

a linear predistorter coupled to said feedback section, said linear predistorter being configured to predistort a forward-data stream that digitally conveys information to compensate for linear distortion introduced downstream of said linear predistorter by said analog-transmitter components; and

a nonlinear predistorter coupled to said feedback section, said nonlinear predistorter being configured to predistort said forward-data stream to compensate for nonlinear distortion introduced downstream of said nonlinear predistorter by said analog-transmitter components; and

a combiner coupled to said linear predistorter and said nonlinear predistorter.

Claim 43 (new): A digital communications transmitter as claimed in claim 42 wherein said feedback section comprises a digital-subharmonic-sampling downconverter.

Claim 44 (new): A digital communications transmitter as claimed in claim 42 wherein:

said feedback section comprises an analog-to-digital converter configured to digitize said RF-analog signal into a return-data stream;

said transmitter additionally comprises a delay element configured to delay said forward-data stream into a delayed-forward-data stream in temporal alignment with said return-data stream;

said transmitter additionally comprises a combiner configured to form an error signal from said delayed-forward-data stream and said return-data stream; and

said linear-predistorter is configured to be trained to compensate for said linear distortion introduced by said analog-transmitter components by implementing an estimation-and-convergence algorithm that converges upon filter coefficients which minimize said error signal.

Claim 45 (new): A digital communications transmitter as claimed in claim 42 wherein:

said feedback section comprises an analog-to-digital converter configured to digitize said RF-analog signal into a return-data stream;

said transmitter additionally comprises a delay element configured to delay said forward-data stream into a delayed-forward-data stream in temporal alignment with said return-data stream;

said transmitter additionally comprises a combiner configured to form an error signal from said delayed-forward-data stream and said return-data stream; and

said nonlinear-predistorter is configured to be trained to compensate for said nonlinear distortion introduced by said analog-transmitter components by implementing an estimation-and-

convergence algorithm that converges upon filter coefficients which minimize said error signal.

Claim 46 (new): A digital communications transmitter as claimed in claim 42 wherein:

said analog-transmitter components include a power amplifier which produces a power-amplifier-output signal;

said transmitter additionally comprises a peak-reduction section configured to process said forward data stream upstream of said nonlinear predistorter and of said linear predistorter; and

said peak-reduction section imposes an amount of peak reduction in said forward-data stream that is responsive to a residual value, said residual value estimating uncompensated nonlinear distortion introduced by said analog-transmitter components into said power-amplifier-output signal.

Claim 47 (new): A digital communications transmitter as claimed in claim 42 wherein:

said nonlinear predistorter comprises a first equalizer which operates in an adaptive mode to compensate for said nonlinear distortion; and

said linear predistorter comprises a second equalizer which operates in an adaptive mode to compensate for said linear distortion.

Claim 48 (new): A method of managing distortion in a digital communications transmitter in which at least a portion of said distortion is introduced by analog-transmitter components, said method comprising:

obtaining a forward-data stream configured to convey digital information;

obtaining an RF-analog signal from said analog-transmitter components;

generating a return-data stream from said RF-analog signal;

implementing a first-estimation-and-convergence algorithm to train a linear predistorter to compensate for linear distortion introduced by said analog-transmitter components; and

implementing a second-estimation-and-convergence algorithm to train a non-linear predistorter to compensate for nonlinear distortion introduced by said analog-transmitter components.

Claim 49 (new): A method as claimed in claim 48 wherein said forward-data stream is provided by a peak-reduction section, said analog-transmitter components include a power amplifier which produces a power-amplifier-output signal, and said method additionally comprises:

obtaining an residual value that estimates uncompensated nonlinear distortion introduced by said analog-transmitter components into said power-amplifier-output signal; and

operating said peak-reduction section so that an amount of peak reduction imposed in said forward-data stream is responsive to said residual value.

Claim 50 (new): A method as claimed in claim 48 wherein said first-estimation-and-convergence and said second-estimation-and-convergence algorithms are each responsive to said forward-data stream and to said return-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said first-estimation-and-convergence and second-estimation-and-convergence algorithms are configured to transform increased algorithmic processing time into reduced effective-error level for said return-data stream.

Claim 51 (new): A method as claimed in claim 48 wherein:

each of said first-estimation-and-convergence algorithm implementing and second-estimation-and-convergence algorithm implementing activities processes said return-data stream;

said forward-data stream exhibits a forward resolution; and

said return-data stream exhibits a return resolution less than said forward resolution.

Claim 52 (new): A method as claimed in claim 48 wherein:

each of said first-estimation-and-convergence algorithm implementing and second-estimation-and-convergence algorithm implementing activities processes said return-data stream;

each of said first-estimation-and-convergence and second-estimation-and-convergence algorithms is responsive to said forward-data stream;

said forward-data stream and said return-data stream exhibit forward-error and return-error levels, respectively, with said return-error level being greater than said forward-error level; and

said first-estimation-and-convergence and said second-estimation-and-convergence algorithms each control a rate of convergence to achieve a predetermined effective return-error level that is less than said return-error level.